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Control System For Cryogenic THD Layering At The National Ignition Facility

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The National Ignition Facility (NIF) is the world largest and most energetic laser system for Inertial Confinement Fusion (ICF). In 2010, NIF began ignition experiments using cryogenically cooled targets containing layers of the tritium-hydrogen-deuterium (THD) fuel. The 75 μm thick layer is formed inside of the 2 mm target capsule at temperatures of approximately 18 K. The ICF target designs require sub-micron smoothness of the THD ice layers. Formation of such layers is still an active research area, requiring a flexible control system capable of executing the evolving layering protocols. This task is performed by the Cryogenic Target Subsystem (CTS) of the NIF Integrated Computer Control System (ICCS). The CTS provides cryogenic temperature control with the 1 mK resolution required for beta-layering and for the thermal gradient fill of the capsule. The CTS also includes a 3-axis x-ray radiography engine for phase contrast imaging of the ice layers inside of the plastic and beryllium capsules. In addition to automatic control engines, CTS is integrated with the Matlab interactive programming environment to allow flexibility in experimental layering protocols. The CTS Layering Matlab Toolbox provides the tools for layer image analysis, system characterization and cryogenic control. The CTS Layering Report tool generates qualification metrics of the layers, such as concentricity of the layer and roughness of the growth boundary grooves. The CTS activities are automatically coordinated with other NIF controls in the carefully orchestrated NIF Shot Sequence.

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